Field Test Program to Develop Comprehensive Design, Operating and Cost Data for Mercury Control Systems on Non-Scrubbed Coal-Fired Boilers

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ABSTRACT

With the Nation's coal-burning utilities facing the possibility of tighter controls on mercury pollutants, the U.S. Department of Energy is funding projects that could offer power plant operators better ways to reduce these emissions at much lower costs.

Mercury is known to have toxic effects on the nervous system of humans and wildlife. Although it exists only in trace amounts in coal, mercury is released when coal burns and can accumulate on land and in water. In water, bacteria transform the metal into methylmercury, the most hazardous form of the metal. Methylmercury can collect in fish and marine mammals in concentrations hundreds of thousands times higher than the levels in surrounding waters.

One of the goals of DOE is to develop technologies by 2005 that will be capable of cutting mercury emissions 50 to 70 percent at well under one-half of today's costs. ADA Environmental Solutions (ADA-ES) is managing a project to test mercury control technologies at full scale at four different power plants from 2000 – 2003. The ADA-ES project is focused on those power plants that are not equipped with wet flue gas desulfurization systems.

ADA-ES will develop a portable system that will be moved to four different utility power plants for field testing. Each of the plants is equipped with either electrostatic precipitators or fabric filters to remove solid particles from the plant's flue gas.

ADA-ES's technology will inject a dry sorbent, such as fly ash or activated carbon, that removes the mercury and makes it more susceptible to capture by the particulate control devices. A fine water mist may be sprayed into the flue gas to cool its temperature to the range where the dry sorbent is most effective.

PG&E National Energy Group is providing two test sites that fire bituminous coals and are both equipped with electrostatic precipitators and carbon/ash separation systems. Wisconsin Electric Power Company is providing a third test site that burns Powder River Basin coal and has an electrostatic precipitator for particulate control. Alabama Power Company will host a fourth test at its Plant Gaston, which is equipped with a hot-side electrostatic precipitator and a downstream fabric filter.

During the first reporting quarter, progress was made on the project in the following areas:

Alabama Power Company Plant Gaston

- Held a site kickoff meeting.
- Began preparation of site test plan.

Wisconsin Electric Power Company Pleasant Prairie Power Plant

- Arranged for site kickoff meeting for late January.
- Evaluated data from previous Apogee/EPRI testing relative to current level of knowledge about the site and planning for future tests under the current project.

General

- ♦ Held a project kickoff meeting.
- ♦ Secured Alabama Power Company Plant Gaston Unit #3 as the fourth test site.
- ♦ Developed a criterion for accepting alternate sorbents for use on the project.
- ♦ Screen tested several Norit products.
- ♦ Started work on ICR Data Integration task.

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EXECUTIVE SUMMARY

ADA-ES began work on a Cooperative Agreement with the Department of Energy in October, 2000 to demonstrate full-scale mercury control systems at coal-fired power plants. The project is the next step in the process of obtaining performance and cost data on full-scale utility plants for mercury control systems. Power generating companies that have entered into contracts with ADA-ES are PG&E National Energy Group, Wisconsin Electric Power Company and Alabama Power Company. During the three-year, $6.8 million project, integrated control systems will be installed and tested at four power plants. ADA-ES is responsible for managing the project including engineering, testing, economic analysis, and information dissemination functions.

During 2000, ADA-ES began designing and specifying system components and initiated contract discussions with key vendors and suppliers to the project. ADA-ES will conduct two demonstration tests during 2001, with two more scheduled for 2002.

On December 14, 2000 the Environmental Protection Agency announced that it will be developing regulations for reducing emissions of mercury from coal-fired power plants. Proposed regulations are expected to be released by December, 2003 and the rules are scheduled to be finalized by December, 2004. It is expected that EPA will include the findings from the ADA-ES/DOE project in its analysis for establishing a mercury control regulation. DOE estimates that the cost to control these emissions will be $2-$5 billion annually.

INTRODUCTION

Mercury is a naturally occurring element, the only metal that exists in liquid form at room temperature. Mercury combines with other elements, such as chlorine, sulfur, or oxygen to form inorganic "salts," typically white powders or crystals. Mercury can also combine with carbon to form organic mercury compounds. Methylmercury is one form organic mercury in the environment, while an ethylmercury salt (thimerosal) has been added to biologics and vaccines since the 1930s to combat bacterial contamination. High levels of mercury can have a toxic effect on the nervous systems of humans. The term "mad hatter" derives from the fact the mercury was used in leather tanning to make hats in previous centuries, and some people so employed develop nervous disorders from continuous exposure to high mercury levels.

Mercury exists in trace amounts in coal, waste and other materials. When these materials burn, mercury gases are released into the air. About 5,000 tons of mercury are released annually into the air in the form of a gas. Mercury vapors can drift in the atmosphere for a year or more, spreading with air currents over vast regions of the globe. The United States accounts for about 3 percent of the world's total mercury emissions. U.S. power plants account for about 1 percent of the world total.

The amount of mercury being deposited today on land and in water is actually much lower today than in recent decades. Peat cores from Minnesota, for example, show that mercury deposition was highest in the 1950s, with levels about 10 times greater than those before 1900. By the 1980s, however, depositions had fallen to less than half of the 1950s. Emissions data from Sweden and measurements of mercury levels in birds and other animals in the United Kingdom also show a consistent pattern suggesting that mercury levels reached a peak around 1960.

Mercury emissions continued to fall in the decade of the 1990s. In 1993, U.S. yearly emissions totaled about 242 tons. By the end of the decade, emissions had declined to less than 160 tons per year.

The primary reason is that the use of mercury in batteries, fungicides and paints has been reduced. Also, municipal waste combustors, hazardous waste combustors, and medical waste incinerators have been regulated by the Environmental Protection Agency (EPA). The number of operating chlor-alkali plants has also declined from about 20 in 1990 to 12 in 2000, and those still operating have reduced their mercury use. Final federal regulations reducing mercury emissions by 90 percent from municipal waste combustors and by 94 percent from medical waste incinerators were released in October 1995 and in August 1997. In 1998 mercury emissions from hazardous waste combustion facilities were also regulated.

EPA is also developing regulations for industrial, commercial, and institutional boilers, process heaters, other non-hazardous solid waste combustors, gas turbines, stationary internal combustion engines, and chlor-alkali plants. In 2001, EPA is scheduled to propose a rule to revise the Land Disposal Restrictions treatment standards applicable to mercury containing wastes.

The Agency made a finding under the Clean Air Act on December 14, 2000, that it is appropriate and necessary to regulate mercury emissions from electric power plants. Although coal-fired power plants contribute only a small part of the total worldwide emissions of mercury - about 1 percent - the 50 tons of mercury they emit annually is about one-third of the total amount of mercury released annually in the United States.

A draft mercury regulation for electric power plants is expected no later than December 15, 2003, and promulgated the following year. Under the expected timetable, regulations would require utility compliance by December 2007 because the Clean Air Act requires sources to install "maximum achievable control technologies" within three years after regulations are promulgated.

The scientific community knows a lot about the human health effects of mercury exposure and has agreed, despite of remaining scientific uncertainties, that mercury is an important human health and environmental problem. Concentrations of mercury in air and water are usually low and cause little direct health concerns. In water, however, mercury can be transformed by bacteria into methylmercury, a more toxic and bioaccumulative form of the metal. Methylmercury levels can build up in predatory fish and marine mammals to concentration levels that are hundreds of thousands of times higher than concentrations in surrounding waters.

People who consume average amounts of a variety of commercially available fish as part of a balanced diet are not likely to take in harmful amounts of mercury. The greatest exposure and risk exist for those persons who regularly eat large amounts of fish from a single location which has been impacted by mercury pollution.

People who consume large amounts of methylmercury-contaminated fish are at risk of adverse effects of methylmercury on the nervous system. Fetuses exposed to methylmercury through their mother's consumption of fish are particularly at risk of adverse effects because the developing nervous system is more vulnerable to mercury toxicity.

The National Academy of Sciences released a report on June 11, 2000, reinforcing the importance, especially for women who may become pregnant, of heeding consumption advisories of noncommercial fish. (There are 1,931 fish consumption advisories in 40 states issued, at least in part, due to mercury. Ten states have issued statewide advisories for mercury in their lakes and/or rivers. Almost 68 percent of all advisories issued in the United States are a result of mercury contamination.)

When the Clean Air Act Amendments were enacted in 1990, mercury was singled out from the 189 substances designated "hazardous air pollutants" because of its potentially harmful effects on humans. Title III of the Act required EPA to determine whether utility boilers in the United States would have to be regulated to reduce emissions of hazardous air pollutants, especially mercury.

In 1993, the Department of Energy's Office of Fossil Energy gave five of the Nation's top environmental monitoring companies the task of assessing the release of trace impurities such as mercury from U.S. coal power plants. The work represented the most intensive effort to date to provide EPA with the critical data it needed on the release of mercury and other toxic impurities from the Nation's power plants.

The initial data collection effort included eight power plants, with measurements taken on the incoming coal and in the gas and wastewater effluents. In 1994, the Energy Department added a coal preparation plant to its study to assess the effectiveness of coal cleaning in removing trace impurities.

In a second phase of the project, eight additional power plants were studied from 1994 to 1996. The results showed that air toxic releases to be the very lowest limits of the most sophisticated detection equipment (approximately 100 parts per billion).

The data also showed that various types of boilers and pollution control devices could have widely varying levels of effectiveness in limiting the release of mercury and other air toxic impurities. DOE's analyses found that about 37 percent of the mercury in coal is removed during coal cleaning processes. Of the approximately 100 tons of mercury still contained in the coal feedstocks entering power plant boilers, about half is captured by existing air pollution control equipment.

But the effectiveness of mercury capture at individual plants can vary, a problem made especially difficult because mercury can be released in both elemental and oxidized forms. Oxidized mercury typically ranges from 30 to 70 percent of the total mercury in flue gas, depending upon the amount of mercury in coal and the way the coal is burned.

Existing pollution control devices such as electrostatic precipitators (which remove solid particles) can be effective in removing oxidized mercury, in some cases up to 90 percent, but they encounter difficulty with the elemental form. Wet scrubbers are effective with oxidized mercury and dry scrubbers can remove both oxidized and elemental, but neither alone reach the emission reductions levels likely to be required. Baghouses also remove oxidized mercury, but the effectiveness depends on the type of filter and other power plant specifics.

In short, pollution control systems can be effective in removing 90 percent of the incoming coal's mercury levels in some cases while in others, very little mercury is removed.

The Energy Department recognized in the early 1990s that while other industries have cost-effective mercury control technologies, none of these is suitable for the coal-fired utility industry. In addition, there is no single technology that can adequately control mercury across the entire utility industry.

Moreover, without better technologies, significant costs could be added to the generation of the nation's electric power. For a 90 percent control level, DOE estimated that annual costs could range between $2 and $6 billion per year (based primarily on tests using activated carbon as the standard process for removing mercury from the flue gas of coal combustion.) The DOE cost analysis became the basis for system-wide estimates of control costs ultimately used by EPA in the 1997 Mercury Study Report to Congress.

In October 1995, the Department's Office of Fossil Energy selected 11 proposals to conduct two years of laboratory- and bench-scale studies of several approaches to controlling mercury and fine particulates from coal-fired utility boilers. In the second phase of the program, five projects were selected to further investigate the most promising of the mercury and fine particulate control technologies and concepts.

In addition, DOE has provided approximately $2 million a year since 1995 on other mercury control development efforts through the Small Business Innovation Research Program, cooperative research with the University of North Dakota Energy and Environmental Research Center, and in several grants to academic research teams through the DOE Fossil Energy University Coal Research Program.

These projects provided a technology base for further development and scale up of mercury emission control technologies. The next step was to obtain performance and cost data on full-scale utility systems.

In March 2000, the DOE Fossil Energy Program, through its National Energy Technology Laboratory, issued a solicitation offering up to $13 million over three years for industry proposals on cost-cutting mercury control methods for coal-based power systems. The department's goal is to develop more effective options that will cut mercury emissions 50 to 70 percent by 2005 and 90 percent by 2010 at one-quarter to one-half of current cost estimates.

In its solicitation, the Energy Department asked for proposals in four specific areas:

1. Field testing of sorbents upstream of existing utility particulate control devices,
2. Field testing of effective mercury control technologies upstream of and across flue gas desulfurization systems,
3. An integrated approach for overall mercury control, and
4. Testing of novel and less-mature controls on actual flue gas systems at the pilot-scale.

Cooperative Agreement No. DE-FC26-00NT41005 was awarded to ADA-ES to demonstrate mercury control technologies on non-scrubbed coal-fired boilers. Under the contract, ADA-ES will work in partnership with PG&E National Energy Group, Wisconsin Electric Power Company, Alabama Power, and EPRI to design and engineer systems to maximize effectiveness and minimize costs to curtail mercury emissions from power plant flue gases. Reports estimate that mercury control could cost the industry from $2 to $5 billion per year. Much of these costs will be associated with power plants that do not have wet scrubbers as part of their air pollution control configurations. The four plants that will be evaluated during the ADA-ES program are typical of this type of application which is found at 75% of the nearly 1100 units that would be impacted by new regulations.

EXPERIMENTAL

No field work was performed during the first quarter of the project. This section provides a summary of the project objectives and methods to be used in the field testing. The contractual statement of work is included in Attachment B for reference.

Program Objectives

With regulations rapidly approaching, it is important to concentrate the development effort on the most mature control technologies. Injection of dry sorbents such as activated carbon into the flue gas and further collection of the sorbent by conventional particulate control devices, electrostatic precipitators (ESPs) and fabric filters, represents the most mature and potentially most cost-effective control technology for power companies. However, all of the work to date has been limited to bench-scale and pilot experiments (Haythornthwaite et al., 1997; Sjostrom et al., 1997). Although these reduced-scale programs provide valuable insight into many important issues, they cannot fully account for impacts of additional control technology on plant-wide equipment. For example, it has been possible to measure high mercury capture at relatively low temperatures in small pilot systems for relatively short periods. However, these lower temperatures may not be practically achieved in a full-scale system continuously without deposition and corrosion in cold spots of ducting and particulate control equipment.

Therefore, it is necessary to scale up the technology and perform full-scale field tests to document actual performance levels and determine accurate cost information. The objectives of this program are to:

- Accelerate the scale-up and availability of commercial mercury control systems for coal-fired plants;
- Obtain data on operability, maintainability, and reliability;
- Determine maximum mercury removal for various plant configurations; and
- Determine the total costs associated with mercury control as a function of fuel and plant characteristics.

This multifaceted field-test program will provide critical data that will be used by many different groups. It will provide EPA with accurate information on the levels of control that can be reasonably attained for different plants. It will complement the emission inventory data obtained during the 1999 ICR data collection effort. Cost and operating data will provide power-generating companies with the means to estimate costs for various plants to perform strategic planning on a system-wide basis. The economic analysis will include:

- Capital costs;
- Sorbent usage costs;

- Impact on operation of particulate control equipment;
- Balance of plant;
- Waste disposal and byproduct utilization issues;
- Enhancements, such as cooling; and
- O&M requirements.

Team Members

ADA-ES has assembled a program team consisting of technical leaders in the areas of mercury measurement, transformations during coal combustion, capture by existing emission-control equipment as well as the design of integrated emission-control systems. Qualifications of individual team members were built by performing pioneering mercury control work in the U.S. over the past decade. Organizations represented on the team include URS Radian, Physical Sciences, Apogee Scientific, EPRI, Energy & Environmental Strategies, EnviroCare, Microbeam Technologies, EERC, Environmental Elements Corp., Consol, Hamon Research Cottrell, and NORIT Americas.

Test Sites

This program is directed at providing sufficient data to determine costs and capabilities for plants that do not have flue gas desulfurization (FGD) systems. This group represents not only the largest proportion of coal-fired power generators (83% by number or 75% by generation capacity), it also represents the most difficult application for mercury control.

To gather data on the application of sorbent injection for removal of mercury from coal combustion flue gas that can be used for as many plants as possible, sites were selected to take into account factors related to the fuel characteristics, the operating conditions of the unit, and interactions with other air pollution control devices. Sites that burn both Eastern bituminous and Western subbituminous coals were included because of differences in speciation of mercury in the flue gas, which greatly affects the efficiency of mercury removal in air pollution control devices. Measurements of the concentration of mercury species taken in the stacks of pilot and full-scale coal combustion systems reported anywhere from 10% Hg^0 to 95% Hg^0 upstream of the air pollution control device (APCD) (Brown et al., 1999). Oxidized mercury, particularly when present as $HgCl_2$, is far easier to capture than is mercury in elemental (Hg^0) form.

In addition to differences in the forms of mercury produced by different coals, the fly ash produced by bituminous and subbituminous coals result in different mercury capture characteristics. For example subbituminous ashes produce higher absorption rates of mercury at higher temperatures and lower LOI values than do ashes from bituminous coals.

There are other important differences between the flue gas produced by Eastern and Western coals. For Eastern bituminous coals a small proportion, 2 to 3%, of the SO_2 is converted to sulfur trioxide (SO_3). SO_3 is important because it reacts with the water vapor to form sulfuric acid. The gas stream for a low-sulfur eastern coal will have sufficient SO_3 that sulfuric acid will begin to condense at 270^{o}F. This means that the gas stream cannot be cooled for enhancement of mercury capture without first eliminating the SO_3 or else severe corrosion of ducting and ESP components would be expected. On the other hand, the higher alkali content of a Western subbituminous coal neutralizes all of the SO_3 resulting in a dew point of 120^{o}F. This means that a flue gas cooling system could be operated without sulfuric acid corrosion. If an SO_3 injection system is used to control particle resistivity in the ESP, its operation must be integrated with the gas cooling system to provide both resistivity control without causing corrosion problems.

Although fabric filters represent only 10% of the current power plant applications, they are an important part of the program because the number of fabric filters could increase significantly as a result of mercury control regulations. If a high level of mercury removal is mandated, a baghouse may be the most economical choice. Meserole (1999) predicts that achieving 80% removal at a plant with an ESP would require 10 times the amount of sorbent as that required if a fabric filter were installed. The difference in the cost of the additional sorbent would be greater than the annualized cost of a new fabric filter.

Figure 1 shows a plot of the distribution of the specific collection areas (SCA) of ESPs for coal-fired boilers. This shows that there is a large number of smaller ESPs (i.e. < 250 ft^2/kacfm) that would have difficulty handling the additional burden of collecting injected sorbent. Therefore, we decided to include a COHPAC baghouse in the test program because COHPAC represents a cost-effective retrofit option for power plants with ESPs. COHPAC is an EPRI-patented concept that places a high air-to-cloth ratio baghouse downstream of an existing ESP to improve overall particulate collection efficiency. Dry sorbents can be injected upstream of COHPAC, downstream of the ESP. The advantages of this configuration are:

- Sorbents are mixed with a small fraction of the ash (nominally 1%) which reduces the impact on ash reuse and waste disposal.
- Sorbent requirements are reduced by a factor of ten relative to the existing ESP
- Capital costs for COHPAC are less than other options such as replacing the ESP with a baghouse or larger ESP.

Table 1 shows a summary of the four power plants that are participating in the field test program. These four plants provide a means to document the performance of mercury control technology for both subbituminous Powder River Basin (PRB) coals and low-sulfur bituminous coals. Three of the plants have ESPs while the fourth plant has both a hot-side ESP and a COHPAC baghouse. This table also presents the expected timing for the four full-scale tests. This schedule was set up to avoid testing either during the summer peak generation season and harsh winter conditions. Table 2 presents data on mercury emissions from three of the four plants as determined during the ICR testing. Additional details on the four plants are provided below.

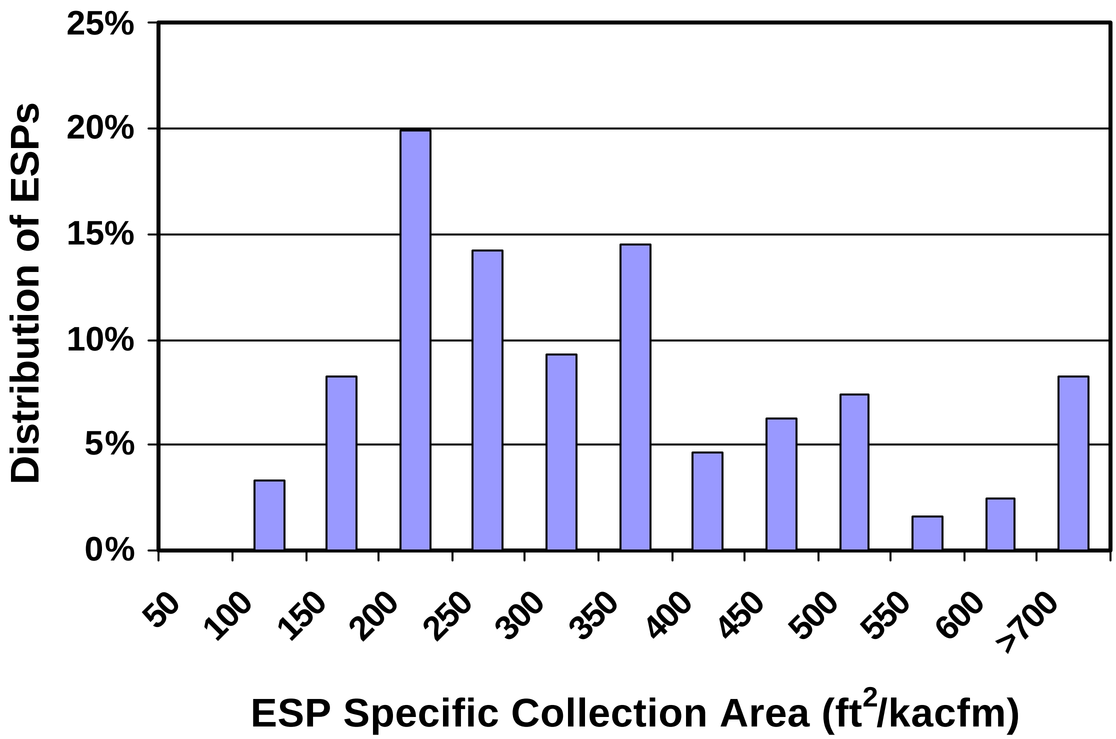


Figure 1. Population Density of ESPs as a Function of SCAs.

Table 1. Host Sites for the Mercury Control Field Test Program

Test Site	Coal	Particulate Control	Field Test Schedule
Alabama Power Gaston	Low S. Bituminous	Hot Side ESP COHPAC FF	Spring 2001
Wisconsin Electric Pleasant Prairie	PRB	Cold Side ESP	Fall 2001
PG&E NEG Salem Harbor	Low S. Bituminous	Cold Side ESP	Spring 2001
PG&E NEG Brayton Point	Low S. Bituminous	Cold Side ESP	Fall 2002

Table 2. Mercury Emissions Data on Three Host Sites

Plant and Unit Sampling Location	Particle Bound	Oxidized, Hg^{2+}	Elemental, Hg^0	Total, Hg
Brayton Point U3				
Inlet (µg/dscm)	1.58	2.53	<1.18	5.30
Outlet (µg/dscm)	0.39	2.09	<1.19	3.67
Removal Efficiency (%)[b]	76.46	16.93	-3.25	31.92
Salem Harbor U3				
Inlet (µg/dscm)	2.83	0.10	0.29	3.22
Outlet (µg/dscm)	0.0554	0.0925	0.2501	0.3980
Removal Efficiency (%)[b]	97.96	-23.07	8.62	87.28
Gaston U1[a]				
Inlet (µg/dscm)	2.26	1.72	2.81	6.80
Outlet (µg/dscm)	0.60	3.99	2.06	6.65
Removal Efficiency (%)	73.45	-131.98	26.69	2.21

a. Measurements made across hot-side ESP not COHPAC baghouse.
b. In ICR test reports, mercury concentration measurements were converted to mass emission rates. The given removal efficiencies are based on the mass emission rates.

Alabama Power E.C. Gaston Unit 3 is a 270 MW B&W wall-fired boiler that burns a washed Alabama bituminous coal. The coal has a heating value of 13,700 BTU/lb and a mercury content of 0.06 µg/g and 0.03% chlorine. Particulate is captured by a Research Cottrell hot-side weighted-wire ESP with an SCA of 274 ft^2/kacfm. This is followed by a Hamon Research Cottrell COHPAC baghouse designed with an air-to-cloth ratio of 8.5:1 gross. The temperature of the baghouse ranges from 240-300 ^oF. During the test program the sorbent will be injected downstream of the ESP and air preheater and upstream of the baghouse.

Wisconsin Electric Pleasant Prairie Power Plant Unit 2 is a 600 MW Riley Stoker balanced draft, turbo-fired boiler that burns PRB coal. The coal has a heating value of 11,897 BTU/lb with mercury content of 0.1 µg/g and 0.0015% chlorine. Particulate is captured by a Research Cottrell cold-side weighted wire ESP with an SCA of 468 ft^2/kacfm. A WAHLCO SO_3 system is used to condition the flyash. The unit operates in a temperature range of 280-310 ^oF.

PG&E National Energy Group (NEG) Salem Harbor Unit 1 is an 85 MW B&W Radiant boiler that fires a South American bituminous coal. The coal has a heating value of 11,300 BTU/lb with mercury content of 0.03µg/g and 0.03% chlorine. Particulate is captured by an

Environmental Elements cold-side rigid-electrode ESP with an SCA of 474 ft^2/kacfm. A FuelTech urea-based SNCR system is used to control NO_x levels. The ESP operates at temperatures as low as 250 ^oF.

<u>PG&E NEG Brayton Point</u> is a 122 MW CE tangential, twin furnace boiler burning a low-sulfur eastern bituminous coal. The coal has a heating value of 12,319 BTU/lb with mercury content of 0.05 μg/g and 0.08% chlorine. A pair of ESPs in series captures particulate. The first is a Koppers weighted-wire cold-side ESP with an SCA of 156 ft^2/kacfm. The second unit is a Research Cottrell rigid-electrode ESP with an SCA of 403 ft^2/kacfm. An EPRICON SO_3 system is used to condition the flyash. The plant uses Separations Technology equipment to process the collected flyash by electrostatically separating LOI carbon from the flyash (Giovando, 2000).

Sorbent Selection and Screening

The test program at each site allows for the evaluation of two sorbents including a lignite-derived activated carbon supplied by NORIT, referred to as Darco FGD carbon, and one alternative sorbent. FGD is considered the benchmark for these tests because of its wide use in DOE/EPRI/EPA sponsored testing. Because of the economic impact of sorbent cost on the overall cost of mercury control, it is desirable to find less expensive sorbents such as flyash-derived products or a less expensive form of activated carbon. A sorbent selection criteria has been developed so that sorbent vendors/developers can clearly understand the needs and requirements of this program. In summary an alternative sorbent must:

- Be at least 25% less expensive than FGD carbon;
- Be available in quantities of at least 15,000 lbs, and potentially as high as 250,000 lbs. for site tests;
- Be available in sufficient quantities to supply at least 100,000 tons per year by 2007; and
- Have a capacity of at least 100 μg/g as measured in the laboratory by URS Corporation.

Sorbents will be tested on a slipstream of flue gas for site-specific mercury capacity using URS Corporations' fixed bed mercury absorption device. This device was developed with funding from EPRI and has been used to screen dozens of sorbents. Adsorption tests are conducted by saturating sorbents with either elemental mercury or mercuric chloride in the presence of simulated flue gas. The test apparatus is illustrated in Figure 2. In the laboratory, simulated flue gas is prepared by mixing heated nitrogen gas streams containing SO_2, HCl, NO_x, CO_2, H_2O, and O_2. Mercury is injected into the gas by contacting nitrogen carrier gas with either recrystallized mercuric chloride solids or with an elemental mercury permeation tube (VICI Metronics) housed in a mercury diffusion vessel. Mercury concentration is controlled by the temperature of the diffusion vessel and the nitrogen carrier gas flow rate. During field screening tests, actual flue gas is drawn into the apparatus.

Sorbents are mixed in a sand diluent prior to being packed in a temperature-controlled, adsorption column (1.27 cm ID). A ratio of 20 mg sorbent to 10 g of sand is generally used for carbon-based sorbents and zeolites, and 200 mg sorbent to 10 g of sand was used for fly ashes.

These mass-loadings are chosen to achieve reasonable mercury breakthrough times with the respective sorbents. Prior to flue gas exposure, the sorbent fixed-bed is heated to the desired temperature for periods up to one hour. During this time, the flue gas is by-passed directly to the analytical system to determine the “inlet” mercury concentration. Adsorption tests were initiated by flowing flue gas downward through the fixed-bed column at a flow rate near 1 L/min. Mercury measurements are made with a mercury semi-continuous emissions analyzer (S-CEM) described later in this section.

The amount of mercury exiting the sorbent column is measured on a semi-continuous basis. Gas is passed through the column until 100% of the inlet mercury is detected at the outlet (100% breakthrough). The 100% breakthrough (equilibrium) capacity of the sorbent (µg Hg/g sorbent) is determined by summing the total mercury adsorbed until the time when the outlet mercury concentration is first equal to the inlet concentration.

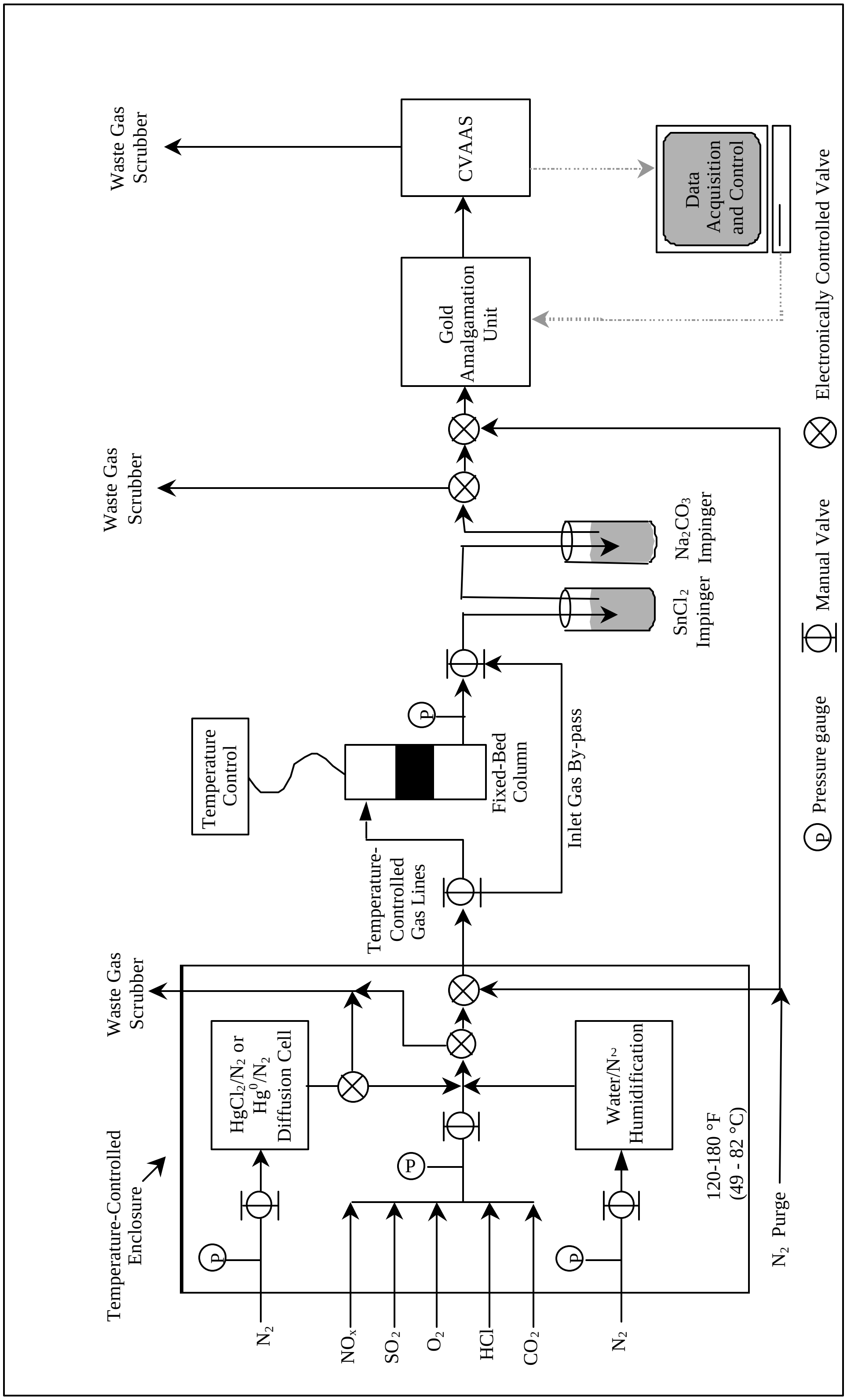
Semi-Continuous Emissions Monitor

Semi-continuous gaseous mercury analyzers built by Apogee Scientific will be used during this program to provide near real-time feedback during baseline, parametric and long-term testing. Continuous measurement of mercury at the inlet and outlet of the particulate collector is considered a critical component of a field mercury control program where mercury levels fluctuate with boiler operation (temperature, load, etc.) and decisions must be made concerning parameters such as sorbent feed rate and cooling. The analyzers that will be used for this program consist of a commercially available cold vapor atomic absorption spectrometer (CVAAS) coupled with a gold amalgamation system (Au-CVAAS). A sketch of the system is shown in Figure 3. One analyzer will be placed at the inlet of the particulate collector and one at the outlet of the particulate collector during this test program.

Although it is very difficult to transport non-elemental mercury in sampling lines, elemental mercury can be transported without significant problems. Since the Au-CVAAS measures mercury by using the distinct lines of UV absorption characteristic of elemental Hg (Hg^0), the non-elemental fraction is either converted to elemental mercury (for total mercury measurement) or removed (for measurement of the elemental fraction) near the sample extraction point. This minimizes any losses due to the sampling system.

For total vapor-phase mercury measurements, all non-elemental vapor-phase mercury in the flue gas must be converted to elemental mercury. A reduction solution of stannous chloride in hydrochloric acid is used to convert Hg^{2+} to Hg^0. The solution is mixed as prescribed in the draft Ontario Hydro Method for manual mercury measurements.

Figure 2. Bench–Scale, Fixed-Bed Mercury Adsorption Test Apparatus.



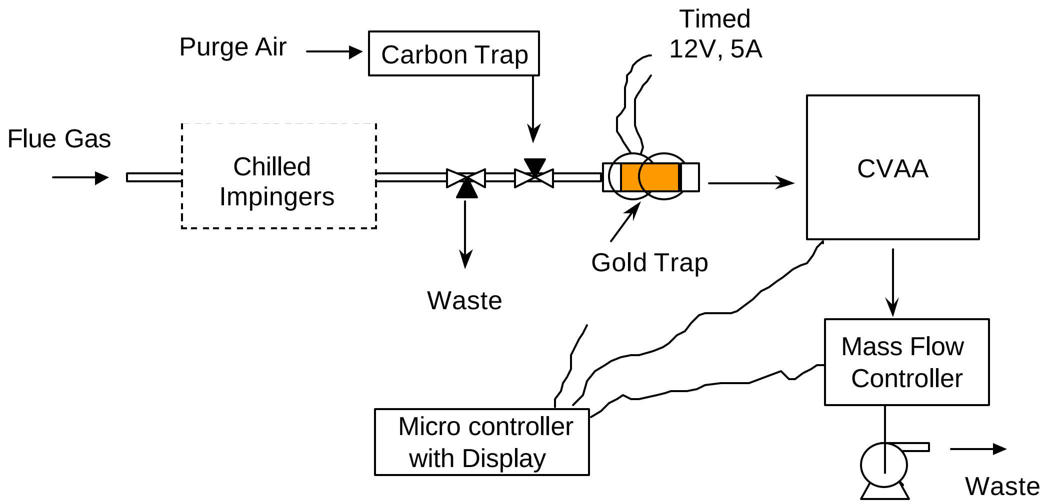


Figure 3. Sketch of Mercury Measurement System.

To measure speciated mercury, an impinger of potassium chloride (KCl) solution mixed as prescribed by the draft Ontario Hydro Method is placed upstream of the stannous chloride solution to capture oxidized mercury. Unique to this instrument is the ability to continuously refresh the impinger solutions to assure continuous exposure of the gas to active chemicals. The Au-CVAAS system is calibrated using elemental mercury vapor. The instrument is calibrated by injecting a metered volume of mercury-laden air from the air-space of a vial containing liquid mercury at a precisely measured temperature into the analyzer.

The Au-CVAAS can measure mercury over a wide range of concentrations. Since the detection limit of the analyzer is a function of only the quantity of mercury on the gold wire and not the concentration in the gas, the sampling time can be adjusted for different situations. Laboratory tests with stable permeation tube mercury sources and standard mercury solutions indicate that the noise level for this analyzer is 0.2 ng mercury. To sample at 50 – 100 times the noise level during field testing, the sampling time is set so at least 10 ng mercury is collected on the wire before desorption. Table 3 shows the sampling time required for different concentrations of mercury in the flue gas with 2 liters per minute sample flow.

Table 3. Sampling Time Required for Au-CVAA Analyzer

Vapor-Phase Mercury Concentration ($\mu g/M^3$)	Minimum Sample Time (min)	Noise Level ($\mu g/M^3$)
5	1	0.1
2.5	2	0.05
1	5	0.02
0.5	10	0.01

Particulate is separated from the gas sample using a self-cleaning inertial gas separation arrangement modified for use with this mercury analyzer under an EPRI mercury control program. This arrangement uses a system where excess sample flow continuously scours particulate from a secondary filter so as to minimize any mercury removal or conversion due to the presence of particulate.

Sorbent Injection Equipment

The sorbent injection equipment is a skid mounted, portable dilute phase pneumatic system. The activated carbon will be delivered to the plant in 900-lb supersacks, which will be stored on pallets adjacent to the injection skid. Operators will load individual supersacks onto the injection skid by a hoist. The reagent is metered by a variable speed screw feeder into an eductor that provides the motive force to carry the reagent to the injection point. A positive displacement blower provides the conveying air. A PLC system is used to control system operation and adjust injection rates. A flexible hose will carry the reagent from the feeder to a distribution manifold located upstream of the particulate collector feeding multiple injection probes inserted into the duct to distribute the sorbent evenly across the flue gas.

Field Testing

Prior to installing injection equipment, preliminary system operation, performance and mercury level measurements will be made. Mercury will be measured using the S-CEM across the particulate control device. These measurements will be used to expedite the parametric evaluation and provide insight as to current mercury removal efficiencies during “normal” operation with varying boiler load. During this test, the S-CEM will be run continuously for a minimum of 24 hours at each site. These data will be used to design the parametric tests with the minimum number of uncontrolled variables.

After installation of the sorbent injection equipment, a second set of baseline tests will be conducted to fully document baseline conditions. During this test boiler load will be held steady at “full-load” conditions during testing hours, nominally 7:00 am to 7:00 p.m. Mercury levels across the particulate control device will be measured using two separate methods: 1) the S-CEM; and 2) standard Ontario Hydro Testing. This baseline test is expected to run for one week.

Following the baseline test, a parametric series of tests will be conducted to document mercury removal levels as a function of injection rate and gas temperature. The flue gas temperature will be lowered at each condition to document the effect of 10 - 20^{o}F decrease in temperature on mercury removal efficiencies. The maximum sorbent injection rate will be established by either a 90% mercury removal level or a sorbent feed proportional to 30 lb/Macf which is considered an economic maximum. The sorbent injection rates to achieve different removal rates will be set with feedback from the S-CEM.

The next series of parametric tests will be conducted using an alternative sorbent. Mercury removal as a function of injection rate will be measured at the optimum temperature measured during the previous test series. After this test the field crew will leave the site to analyze data and work with team members on establishing conditions for the long-term test.

The final test will be a mercury removal validation program conducted for a maximum of fourteen days at the "optimum" plant operating conditions (lowest cost/highest mercury removal) as determined from the parametric tests. The S-CEM will be used for continuous monitoring of mercury removal. Ontario Hydro measurements at the inlet and outlet will be conducted.

Waste Characterization

During each field test program, samples of the ash/sorbent mixture from the hoppers will be collected and analyzed. The standard testing technique used for assessing hazardous waste characteristics is the Toxicity Characteristic Leaching Procedure (TCLP, SW846-1311). A 100-gram sample of ash is exposed to 1-liter of acidic solution (acetic acid-or acetate based) for 24 hours. The solution is then analyzed for several metals (including mercury) to determine how much of each target metal was leached from the solid sample. Results are compared against limits established by regulation. In the case of mercury, a maximum leachable level of 0.2 mg/liter has been established.

A second series of tests will be performed to answer the question of the stability of the mercury. The potential long-term environmental impact of the mercury-laden ash will be determined using two techniques, leaching and thermal desorption. The Energy and Environmental Research Center (EERC) will conduct these tests. Leaching tests are done using a method known as the synthetic groundwater leaching procedure (SGLP) (Hassett, et al., 1999). This test is modeled after the TCLP, but modified to allow for disposal scenarios. A shake extraction technique is used to mix the solid sample with an aqueous solution. Aliquots of the liquid are then analyzed after 18 hours, 2 weeks, and 4 weeks. Thermal desorption tests will be performed using a special test fixture that is heated using a programmable temperature controller. The temperature of the ash sample is ramped to 500 ^{o}C at a rate of 20 ^{o}C per minute. Mercury that is released by the sample is swept to a spectrophotometer for mercury measurement as a function of time and temperature.

Design and Economics of Site Specific Control System

After completion of testing and analysis of the field data, the requirements and costs for full-scale, permanent commercial implementation of the necessary equipment for mercury control using sorbent injection technology will be determined. Process equipment shall be sized and designed based on test results and the plant specific requirements (reagent storage capacity, plant arrangement, retrofit issues, winterization, controls interface, etc.). A conceptual design document shall be developed with drawings and equipment lists. Modifications to existing plant equipment shall be determined and a work scope document developed based on input from the plant which may include modifications to the particulate collector, ash handling system, compressed air supply, electric power capacity, other plant auxiliary equipment, utilities and other balance of plant engineering requirements. Reagent type and sources shall be evaluated to determine the most cost effective reagent(s) for the site.

Technology Transfer

Transferring the information generated during this program to the coal-fired power generation industry will be an important part of the program. This will be accomplished through technical papers presented at various forums including AWMA annual meeting, ICAC meetings, AWMA Specialty Conferences on mercury, and the EPRI/DOE/EPA MEGA Symposium. In addition, results from the test programs will be made available to the public as soon as they are completed and approved by DOE and the host power generating companies. We will use the ADA-ES website (www.adaes.com) to distribute these reports.

The following technology transfer activities were conducted during the first quarter of the project:

- ADA-ES has issued several press releases related to the project,
- Host site power companies have issued press releases,
- DOE prepared a TechLine and numerous references to the project on its NETL web site,
- EPRI has been actively participating in the project and assisting in organizing technical forums to present information about the project (EPRI is recognized as a world leader in creating science and technology solutions for the energy industry and for the benefit of the public and currently serves more than 1000 energy organizations worldwide),
- Alabama Power Company presented a feature story on the project in a company newsletter *Powergrams*, and
- ADA-ES publishes a semiannual newsletter (*"Solutions"*). The December 2000 edition was sent to 3,400 mailing list recipients and featured an article on the project. Project updates will be published in the newsletter in the future.

Attachment C contains several news releases and announcements on the project.

In addition to the above planned activities, a great number of articles/announcements have been written by news media as a result of picking up the news releases issued from the project team. Articles/announcements have been written in Coal Daily, Clean Air Compliance, Power Online, Power Engineering, Chemical Engineering, Air Daily, Pollution Online, Chemical Engineering Progress, Electric Light & Power, Coal Outlook, and a number of local and national newspapers.

RESULTS AND DISCUSSION

A project kickoff meeting and organizational activities were conducted during the first quarter of the project. Field testing is planned for the second quarter. Detailed results of the testing at each power plant will be provided in separate topical reports.

CONCLUSION

Work began on Cooperative Agreement No. DE-FC26-00NT41005 in October 2000. Initial activities include holding a project kickoff meeting, securing the fourth test site (Alabama Power Company Plant Gaston), and performing various planning and administrative functions.

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LIST OF ACRONYMS AND ABBREVIATIONS

APCD	Air Pollution Control Device
AWMA	Air & Waste Management Association
B&W	Babcock and Wilcox
CE	Combustion Engineering
COHPAC	Compact Hybrid Particulate Collector
CVAAS	Cold Vapor Atomic Absorption Spectrometer
DOE	Department of Energy
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
FGD	Flue Gas Desulfurization
ICAC	Institute of Clean Air Companies
ICR	Information Collection Request
PLC	Programmable Logic Controller
PRB	Powder River Basin
SCA	Specific Collection Area
SGLP	Synthetic Groundwater Leaching Procedure
TCLP	Toxicity Characteristic Leaching Procedure

ATTACHMENT A

Accomplishments and Status Assessment
October 1 – December 31, 2000

General

- The Cooperative Agreement was started on October 1, 2000. Began placing subcontracts with those organizations that have planned activities in early months.
- A project kickoff meeting was held on October 31, 2000. The meeting was important to set the groundwork for conducting the project. Details of each test site were discussed, and a priority test schedule was established to include conducting pre-baseline measurements at all plants during early 2001, performing the site tests at Plant Gaston in early 2001, performing the testing at Pleasant Prairie Power Plant beginning in late 2001, testing Salem Harbor and then testing Brayton Point.
- Began negotiating with Southern Company for including Gaston Unit #3 (COHPAC configuration) as the fourth test site.
- Began planning the configuration of the transportable control system and mobile staging trailer.
- Acquired samples of several alternative Norit products and submitted for mercury uptake testing to Dr. Carl Richardson of URS Group.
- Developed a criterion for accepting sorbents for inclusion in the sorbent screening phase of the program.
- Met with Norit Americas in early December, 2000. Norit will be supplying the carbon injection system for use on the project and will contribute to the design and modifications required for adapting their equipment for our tests.
- A Land dew point analyzer was acquired for use on the project.
- ADA-ES is planning the purchase of an on-line LOI analyzer that will be made available for use on the program.
- Started initial work on ICR Data Integration task.

Alabama Power Company Plant Gaston

- Held a site kickoff meeting with Southern Company on 12/4 and 12/5/00.
- A Southern Company press release on the project was issued on 12/11/00.
- Preparing site test plan.

Wisconsin Electric Power Company Pleasant Prairie Power Plant

- Met with Apogee Scientific and EPRI to discuss test results of the work that Apogee and EPRI have done at Pleasant Prairie Power Plant during 2000. The information was also discussed with EEC and WEPCo. The Apogee/EPRI testing focused on characteristics of the flue gas stream and sorbent screening test results. Suggestions for follow-up tests were made in order to better define sorbent and hardware configurations for the DOE testing. EEC is tasked with preparing a test plan, performing ESP modeling calculations to assess the impact of fly ash recycle, and to perform calculations of sorbent injection rates for equipment sizing purposes. We are seeking formal approval to release all or part of the Apogee/EPRI information to project team members.
- Preparing materials for site kickoff meeting to be held 1/26/01.

ATTACHMENT B

Statement of Cooperative Agreement Objectives
Cooperative Agreement No. DE-FC26-00NT41005

A. Objectives

The overall objective of this project is to determine the cost and impacts of sorbent injection into particulate control devices for various mercury removal levels at full-scale, coal-fired power plants.

B. Scope of Work

The scope of work is for one, three-year long budget period and intended to provide the necessary information to assess the costs of controlling mercury from coal-fired utilities by examining the economics of various levels of mercury control (at different temperatures) at four different host sites. Testing will be conducted on a minimum of three different configurations that represent a significant percentage of existing units. These configurations will include the following: an electrostatic precipitator collecting ash from a powder river basin subbituminous coal; electrostatic precipitators collecting ash from a low-sulfur eastern bituminous coal burned in low-NO_x burners with selective non-catalytic reduction (SNCR); and a baghouse configuration filtering ash from powder river basin subbituminous coal. The subsequent cost analyses will include capital costs, byproduct utilization issues, sorbent usage, any necessary enhancements, such as SO_3 control or flue gas conditioning, balance of plant, manpower requirements and waste issues.

C. Statement of Work

The Project is divided into 13 tasks. Each task addresses one or more of the Project objectives. A description of these tasks is presented below.

Task 1 - Design and Fabrication of Transportable Mercury Control System

The participant shall design a transportable mercury control system with the ability to provide both humidification and carbon/sorbent injection to a minimum of two flue gas ducts simultaneously. Components shall be skid or panel mounted for relatively quick and easy set-up/tear-down at each site. This system shall be sized and designed to cover the range of plant sizes from 50-150 MW. This system shall have the ability to be operated with both baghouses and electrostatic precipitators. The participant shall design and size humidification injection lances for each plant application separately based on duct dimensions and water flow requirements. The sorbent injection system shall provide high flow (100-1500 lbs./hr) and low flow (10-200 lbs./hr) capability depending on the amount of required sorbent injection. The participant shall hold a design review meeting including the DOE COR, equipment suppliers, and site-specific engineers before finalizing the transportable mercury control system design and fabrication. The participant shall submit the final design specifications to the DOE COR. After design specifications are finalized, the participant shall fabricate the transportable mercury control system. Any host-site components that are necessary to interface with the transportable mercury control system shall be identified at least forty-five days prior to the start of the scheduled host site field test to allow adequate design time to accommodate the specific plant arrangements and ductwork configurations.

Tasks 2-9 will be common to each field test site and will be repeated for each site that comes under a host site agreement.

Task 2 - Kickoff Meeting, Test Plan and Project Management Plan

The participant shall schedule and attend a kickoff meeting at each host site with the appropriate plant, project, and environmental personnel. The participant shall discuss the overall scope of the Project, the potential impact on plant equipment and operation and obtain information necessary to develop a detailed test plan and Project management plan. These documents shall be available for host site personnel to use when addressing permitting, scheduling and operating issues. The final test plan shall be completed 30 days prior to testing and require concurrence from both the host site and DOE COR. The participant shall also prepare a Project management plan that includes coordination, accounting, and project tracking activities for each host-site field test.

Task 3 - Sorbent Selection

The participant shall select at least two sorbents for evaluation during the full-scale tests. These sorbents shall include at least one standard activated carbon sorbent and one site-specific sorbent that demonstrates the best capacity for mercury uptake based on mercury concentration, gas composition, temperature, and mixing.

Subtask 3.1 - Activated Carbon Screening:
The participant shall characterize the physical and chemical properties of a given activated carbon followed by bench-scale, fixed-bed tests to determine the equilibrium adsorption capacity and breakthrough characteristics. The sorbent shall be commercially available at a cost less than $.50/pound.

Subtask 3.2 - Site-Specific Sorbent Screening:
The participant shall evaluate the potential of alternate sorbents, including fly ash based products, to remove mercury considering key factors such as carbon content, pore volume, surface area, and particle size distribution. The participant shall characterize the performance potential of candidate sorbents using equilibrium adsorption capacity data generated from fixed-bed, laboratory experiments with simulated flue gas.

All selected sorbents will be tested at the host site using a slipstream of gas from full-scale systems. Additional site-specific sorbents shall also be tested if the results from screening tests are promising and availability and cost are reasonable. Samples of the candidate and selected sorbents shall be supplied to DOE if requested by the COR.

Task 4 - Design and Fabrication of Site-Specific Equipment Needs

The participant shall identify site specific components to be provided by the host utility. These components shall be sized and designed for the specific plant arrangements and ductwork configurations. Site specific equipment includes but is not limited to the following:

Humidification System
Injection Ports
Platforms/Scaffolding
Lance Hoist
Injection Lances (if possible these components will be re-used)
TC Array (if possible these components will be re-used)
Compressed Air
480V Power, 110V Power
Freeze Protection
Signal Wiring
Water Supply
Balance of Plant Engineering

Activated Carbon (AC) / Sorbent Injection System
Injection Ports
Sorbent Distribution Manifold
Sorbent Injectors (if possible these components will be re-used)
Cherry Picker for Supersacks
Compressed Air
480V Power, 110V Power
Boiler Load Signal
Signal Wiring
Balance of Plant Engineering

The participant shall insure the host utility obtains all permitting and variance requirements. In addition, the participant shall make arrangements with the host utility to isolate fly ash from the test unit during sorbent injection.

Task 5 - Field Testing

The field tests shall be accomplished through a series of nine (9) subtasks. The subtasks shall be independent from each other in that each shall have specific goals and tests associated with them. However, they shall also be interdependent with the results from each task influencing the test parameters of subsequent tasks.

Subtask 5.1 - Pre-Baseline Measurements:
The participant shall make preliminary system operation, performance and mercury level measurements prior to the start of equipment installation. The mercury shall be measured at both the inlet and outlet of the air pollution control device using a semi-continuous emissions (S-CEM) monitor for both total and speciated mercury concentrations. These measurements shall be used to expedite the parametric evaluation, provide insight as to how mercury levels and removal efficiencies change in a transient and steady-state manner with varying boiler operation and to allow for the timely completion of the test plan. The participant shall verify the S-CEM by comparing its results to those obtained by Ontario-Hydro testing. During this period, the S-CEM shall be run continuously for a minimum of 3 days. These data shall be used to understand the relationship between boiler operation (load and combustion conditions), control device inlet temperature, and fly ash properties (fly ash concentration and carbon content at the inlet and outlet of particulate matter control device and collection efficiency). The participant shall use these results in the design of parametric tests to reduce the number of uncontrolled variables.

Subtask 5.2 - Sorbent Screening:
The participant shall screen selected sorbents on actual flue gas prior to the start of equipment installation. The participant shall select the most promising sorbent/s based on these results and in coordination with Task 3.

Subtask 5.3 - Site Modifications, Equipment Installation and System Checkout
The participant shall oversee installation and checkout of the mercury control equipment. Procedures developed shall be similar to those used in the commercial installation of other flue gas conditioning systems. The participant shall work with the host utility to assure that the equipment is installed in an efficient manner, within the resources available at the site. In addition, the participant shall make arrangements with the host utility to isolate fly ash from the test unit during sorbent injection. The participant shall be responsible for final checkout of all systems and for the general maintenance of the systems during testing.

Subtask 5.4 - Quality Assurance and Quality Control (QA/QC) Plan
The participant shall prepare a QA/QC plan to control, evaluate, and document data quality to ensure that data generated are of the highest quality possible. The participant shall submit the QA/QC plan for DOE (and EPA if an agreement is negotiated between DOE and EPA) approval 30 days prior to each host-site field test. The plan shall be EPA ORD Level 2 compliant and document that specific procedures that shall be adhered to and include data quality objectives and data quality indicator metrics to achieve them. The plan shall address:

- QA/QC procedures associated with in sample collection, analytical and data analysis
- Integral performance evaluation and verification of Hg removal
- Data validation
- Data Treatment
- Procedural remedies for identified data deficiencies
- Oversight and documentation of all QA/QC.

Other key questions the plan shall address include what will be done with the data, how will it be analyzed, will any duplicate (co-located) sampling take place, and what is the measurement precision. Table 1 summarizes several of the QA/QC activities DOE would like to consider. DOE reserves the right to coordinate with EPA to further refine required QA/QC activities.

Table 1. QA/QC Activities

Property/Test	QC Check	Frequency	Acceptance	Corrective Action
Hg in Flue Gas, Ontario Hydro (draft)				
Sampling	Equipment Calibration	Pre/Post Test	Refer to method	Repeat calibration
	Field Blank	One per sampling location	Within <20% of measured Hg	Flag data
Analytical	Analyze in Duplicate	All samples	Agreement within 10%	Repeat analysis
QAPP DQI	Analyze spike	Once per 10 samples	Refer to method	Repeat analysis
Particulate, EPA Method 5				
Sampling	Equipment Calibration, Leak Test	Pre/Post Test	Refer to method	Repeat test or correct data
	Field Blank	One per sampling location	Refer to method	Repeat test or correct data
Analytical	Control	One per triplicate test	Refer to method	Repeat analysis
Duct Opacity, CEM	Integral Calibration and correction	Continuous	Per Performance Spec. 1, 40CFR60, App. B	Recalibrate
Mercury Analyzer, Au-CVAAS	Calibration with pre/post test zero/span drift checks	Per participant QC procedures	To be developed	Flag data, recalibrate instrument
TCLP, EPA SW 846 Method 1311	Per Method for RCRA metals	Refer to method	Refer to method	Flag data
Fly ash Analysis, Concrete ASTM C-618	Test Procedures according to ASTM C311	Refer to method(s)		
	Duplicate samples	One per test series	To be developed	Flag data
Coal Analysis, total Hg ASTM D6414-99	NIST Standard Reference Material fly ash	One per laboratory	Per method	Repeat analysis
Fly ash Analysis, total Hg ASTM D6414-99	NIST Standard Reference Material fly ash	One per laboratory	Per method	Repeat analysis

<u>Subtask 5.5 - Baseline Testing</u>:
After equipment installation, the participant shall make a second, shorter set of baseline tests at conditions expected during the parametric tests. The participant shall ensure constant boiler load, standard soot blowing, and normal ESP rapping sequences or baghouse cleaning logic. The participant shall collect data during baseline operation that include the parameters identified in Table 2.

Table 2. Baseline Parameters

Parameter	Sample/signal/ test	Baseline	Parametric/ Long-Term
Coal	Batch sample	Yes	Yes
Coal	Plant signals: burn rate (lb/hr) quality (lb/MMBTU, % ash)	Yes	Yes
Fly ash	Batch sample	Yes	Yes
Unit operation	Plant Signals: Boiler load Measure of flow for partial unit test (i.e. fan amps)	Yes	Yes
Temperature	Plant signal at particulate collector inlet and outlet	Yes	Yes
Temperature	Full traverse, inlet & outlet	Yes	No
Average Temperature	Before spray cooling After spray cooling	No	Yes
Duct Gas Velocity	Full traverse, inlet & outlet w/ Draft Ontario-Hydro method	Yes	No
Mercury (total and speciated)	Full traverse, inlet & outlet of APCD	Yes	No
Mercury (total and speciated)	Single point, inlet & outlet of APCD (Au-CVAAS) S-CEM verified by draft Ontario Hydro	Yes	Yes
Mercury (total and speciated)	Ontario Hydro, inlet and outlet of APCD	Yes (2 sets) Every 12 hours	Yes (2 sets)
Spray Cooling Rate	PLC, gal/min	No	Yes
Sorbent Injection Rate	PLC, lbs/min	No	Yes
CEM data (NO_x, O_2, SO_2)	Plant data – stack	Yes	Yes
HCl,Cl_2 (optional) and SO_3 (optional)	FTIR and controlled condensation	Yes	Yes
Stack Opacity	Plant data	Yes	Yes
Pollution control equipment operation	Plant data (ESP power, baghouse cleaning, etc.)	Yes	Yes

<u>Subtask 5.6 - Parametric Test Series 1: Mercury Removal as a Function of Temperature:</u>
The participant shall conduct a series of parametric tests to determine the impact of inlet temperature on mercury removal efficiency across the particulate collection device. The participant shall define an operating window for temperature where maximum mercury removal can be obtained with a very low risk of duct deposition from spray cooling with water. The parametric tests shall show the effects of boiler operating conditions and sorbent injection parameters for temperatures less than 300^{o}F. Temperature shall be incrementally lowered to determine the effect of temperature and sorbent injection parameters on mercury removal and operational feasibility with the goal of obtaining maximum mercury removals. The participant shall pull the lances at least once per day during the tests to inspect for deposits forming around the nozzles and utilize an in-duct camera to monitor duct deposition.

<u>Subtask 5.7 - Parametric Test Series 2: Mercury Removal as a Function of Sorbent Injection</u>:
The participant shall evaluate mercury removal as a function of sorbent injection rate at both the “normal” and optimized temperatures. The goal of this task shall be to define the quantity of sorbent required to obtain three different levels of mercury removal between 40% and 90% of the remaining mercury. The

participant shall determine the optimum combination of cooling and sorbent injection required from subtask 5.6 data and input from available models. The optimum combination shall be based on a lowest-cost approach to a desired removal rate. The participant shall determine the operational time at each setting based on the time necessary to collect adequate operating/performance data. The participant shall utilize these results to determine the settings for the long-term test. These tests shall also be used to optimize performance and operation of the particulate control device. The participant shall provide additional flue-gas conditioning additives for particle resistivity and/or reentrainment if required.

DOE may provide (or coordinate with the prime participant) for additional sampling during the parametric testing. DOE would primarily be concerned with co-pollutant control measurements of SO_3, HF, NO_x, HCl, and fine particulate matter.

Subtask 5.8 - Parametric Test Series 3: Mercury Removal as a Function of Alternate Sorbent Injection:
The participant shall perform a set of parametric tests for evaluation of site-specific sorbent/s. These tests shall be conducted in a similar manner as those in subtask 5.7.

Subtask 5.9 - Long-Term Testing:
The participant shall perform mercury removal validation testing for a maximum of fourteen days at the "optimum" plant operating conditions (lowest cost/highest mercury removal) as determined from the parametric tests. The participant shall obtain DOE and host utility concurrence on the exact length of testing. The participant shall use commercially available semi-continuous mercury analyzers capable of measuring 0.1 micrograms per normal cubic meter of mercury at the inlet of the particulate collector and at the outlet of the particulate collector during this test Project to provide near real-time feedback. The participant shall calibrate the S-CEM every three days. The participant shall also make Ontario-Hydro measurements at the inlet and outlet of the particulate control device during testing. The participant shall strive for a leak-free sampling system. The participant shall place an oxygen analyzer downstream of the S-CEM to monitor and store the oxygen levels in the gas stream. The participant shall configure the gas sampling system in a manner to minimize any mercury removal or conversion due to the presence of particulate. The participant shall prepare a preliminary report on the removal efficiency over time, the effects on the particulate control device and balance of plant equipment, and on operation of the injection equipment to determine the viability and economics of the process.

Task 6 - Data Analysis

The participant shall optimize data collection for the four host-sites measured and prepare a summary report on the effect of the combination of temperature and sorbent injection on mercury control and their impact on the existing pollution control equipment. The participant shall characterize mercury levels and plant operation for baseline conditions (no modification of temperature or sorbent injection), various temperatures and injection rates as defined by the final test plan, and a long term evaluation to identify effects that may not be immediate. The participant shall collect samples of coal and fly ash during baseline testing for analysis. The participant shall conduct a full analysis of the coal including the mercury, chlorine and sulfur levels. The fly ash shall be analyzed for mercury and carbon content. Fly ash samples shall be collected from multiple locations when appropriate to determine if there is mercury segregation throughout the system or across the particulate collector. The participant shall conduct a full temperature, velocity and mercury (total and speciated) traverse at the inlet and outlet of the particulate collector during full-load conditions to determine profiles for appropriate sampling, humidification, and sorbent distribution. Following a complete mercury traverse using a S-CEM, the S-CEM shall be placed at the inlet to the particulate collector at a location identified from the traverse to represent the average duct concentration. While the first S-CEM is operating, a second S-CEM shall be connected to the same probe to verify that both are measuring the same mercury concentration. The second S-CEM shall then be moved to the outlet of the particulate collector at a location identified from the traverse to indicate the duct average concentration. The participant shall obtain a triplicate manual mercury sample using the draft Ontario Hydro Method at the inlet location through a probe common to the inlet analyzer to verify operation of the analyzers. The participant shall monitor different plant signals to determine if any correlation exists between changes in mercury concentration and measured plant operating conditions.

Task 7 - Waste Characterization

The participant shall evaluate the stability and form of mercury in the ash for disposal and reuse purposes. The participant shall also evaluate changes in ash characteristics that impact utilization (e.g. increased carbon content, elevated mercury concentrations). The participant shall utilize three series of standard procedures to assess the environmental stability of the ash and suitability for use in concrete. These tests consist of the Toxicity Characteristic Leaching Procedure (TCLP, SW846-1311), ASTM Specification C618 with air entrainment shaker tests, synthetic groundwater leaching procedure (SGLP), and thermal desorption (see Table 3). The participant may perform additional tests on selected byproduct samples as needed to assess special site-specific conditions that impact disposal or reuse options. The participant shall analyze selected samples of the fly ash for size, composition, and abundance of the ash particle types (for any host site that incorporates carbon separation). The participant shall obtain these grab samples of ash from control device hoppers during each day of testing. Samples shall be segregated by the test condition (baseline, each parametric test, and long-term test) and composited in 55-gallon drums with appropriate quantities placed into sample containers for shipping to the analytical laboratories. The participant shall collect samples of the carbon-rich fraction in a similar manner as the ash samples for any host site that has a carbon separation process. Sampling and compositing procedures shall follow the protocol of ASTM C311 (Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete).

Table 3. Summary of Waste Characterization Testing

Series	Test Purpose	Test Method	Comments
1	Ash Disposal	TCLP (SW846-1311)	Measures leachable Hg, As, Ba, Cd, Cr, Pb, Se, Ag
2	Cement Additive Suitability	ASTM C618 Air Entrainment Shaker Test	Measures LOI, total oxides, sulfur trioxide, moisture, available alkalines, fineness, pozzolanic activity, autoclave soundness, specific gravity, air entrainment
3	Environmental Stability – Leaching	EERC SGLP	Measures leachable Hg at 18 hrs, 2 weeks, and 4 weeks
	Environmental Stability – Air Release	EERC Thermal Desorption	Measures Hg release as a function of temperature up to 500 ^{o}C
4	Special Testing	Various	As needed for troubleshooting or site specific information needs

Notes: 1.Two samples from each test condition shall be analyzed for TCLP and ASTM C618/Air Entrainment parameters. One sample from each test condition shall be tested for SGLP, and Thermal Stability. Additional samples may be analyzed after the initial results are available and have been reviewed.
2. For those situations where it may be important to look at front and back hoppers separately, samples may be segregated and analyzed as a function of ESP field.

The participant shall collect ash samples from each host site per the sampling frequency and volume identified in Table 4.

Table 4. Ash Sampling Schedule and Volumes – Each Host Site

Test Condition	Frequency	Comments
Baseline	Once Before Parametric Testing	110-gal. sample
Parametric Test #1	Grab Samples Daily for 1-week	110-gal. total sample
Parametric Test #2	Grab Samples Daily for 1-week	110-gal. total sample
Parametric Test #3	Grab Samples Daily for 1-week	110-gal total sample
Long-term Test	Grab Samples Daily for 2-week	220-gal total sample

Task 8 - Design and Economics of Site-Specific Control System

After completion of testing and analysis of the data at each plant, the participant shall determine the requirements and costs for full-scale, permanent commercial implementation of the necessary equipment for mercury control using sorbent injection with humidification technology. The participant shall meet with the host utility plant and engineering personnel to develop plant specific design criteria. Process equipment shall be sized and designed based on test results and the plant specific requirements (reagent storage capacity, plant arrangement, retrofit issues, winterization, controls interface, etc.). A conceptual design document shall be developed with drawings and equipment lists. Modifications to existing plant equipment shall be determined and a work scope document developed based on input from the plant which may include modifications to the particulate collector, ash handling system, compressed air supply, electric power capacity, other plant auxiliary equipment, utilities and other balance of plant engineering requirements. Reagent type and sources shall be evaluated to determine the most cost -effective reagent(s) for the site. Cost credits/penalties for fly ash salability shall be estimated. The participant shall prepare a cost estimate to implement the control technology. This shall include capital cost estimates for mercury control process equipment as well as projected annual operating costs. Where possible, order-of-magnitude estimates will be included for plant modifications and balance of plant items.

Task 9 - Site Report

The participant shall prepare a site report documenting all measurements, test procedures, analyses, and results obtained in Tasks 2 through 8. This report shall be a stand-alone document providing a comprehensive review of the testing and data analyses completed at each host site.

Task 10 - Information Collection Request (ICR) Data Integration and Economic Analysis

This task consists of two subtasks.

Subtask 10.1 - ICR Data Integration

The participant shall prepare a database to catalog the level of mercury currently removed using ESP's and FF's without additional mercury controls. The participant shall populate this database with ICR Phase I, II, and III information showing plant configuration (boiler type, size, and emission control equipment, ESP or FF), fuel data (Btu, ash, sulfur, chlorine, and mercury), and mercury emission data (total and speciated) for the given load and temperature. The participant shall use the database to characterize the baseline ICR mercury removal as a function of fuel (type, chlorine content, etc.), configuration (ESP or FF), temperature and ash carbon content. The participant shall compare host sites' fly ash analyses (including mercury concentration and carbon content in fly ash) with any available plants' fly ash samples that were collected during ICR testing. The participant shall then integrate the host site field data with the database to identify any general trends. The participant shall specifically address mercury removal as a function of flue gas temperature, the effect of carbon content (native and re-injected) on mercury removal, and a comparison of fly ash (with varying levels of unburned carbon) to activated carbon for mercury removal effectiveness. The participant shall also compare the database to EPRI's sorbent injection model which utilizes sorbent characteristics, mass transfer theory, and sorbent residence time in the duct.

Subtask 10.2 - Integrated Economic Analysis

The participant shall determine the costs of controlling mercury emissions from coal-fired power plants by conducting economic analyses on various mercury control technologies. After completion of all host-site testing, the participant shall submit a detailed economic analysis plan for DOE COR approval. This plan shall discuss the recommended economic methodology for evaluating electric utility industry costs as well as specific cost considerations and assumptions (including the requirements listed below). These economic/cost evaluations shall update and expand upon previous DOE cost assessments. The participant shall use the results from the host site tests in conjunction with detailed engineering cost estimates, reagent cost and transportation projections, impacts on downstream equipment, and O&M to determine full scale commercial costs for each fuel/plant/control configuration identified in Table 5.

Table 5. Fuel/Plant/Control Configuration

Coal Type	Existing Particulate Control	Mercury Control System
PRB	ESP	AC w/ cooling
PRB	ESP	AC, cooling, polishing FF
PRB	FF	AC
PRB	FF	AC w/cooling
Eastern Low S	ESP	AC w/ cooling
Eastern Low S	ESP	AC, cooling, polishing FF
Eastern Low S	FF	AC
Eastern Low S	FF	AC w/cooling

The participant shall determine costs for two reference plants, one of 150MW size and one of 500MW size. The economic analyses shall include the following:

Capital Costs
Mercury control process equipment
Modifications/upgrades to existing plant equipment

Variable and Fixed Operating and Maintenance Costs
Reagents
Power
Maintenance Labor and materials
Fly ash utilization penalties

Present Worth of Revenue Required

Cost Sensitivity Studies
Plant size
Mercury control level
Uncontrolled Mercury
Reagent costs
Cooling level
Remaining plant life

Levelized Control Costs
First Year Fixed and operating costs
15 year levelized costs ($/ton of carbon removed)

Task 11 - Technology Transfer

The participant shall attend and present project results at a minimum of three mercury-control technology symposiums identified by collaboration with the DOE COR.

Task 12 - Equipment Disposition Plan

The participant shall also prepare a detailed plan for maintaining/disposing of all project related equipment following the project including the transportable mercury treatment system consisting of carbon injection equipment, reagent injection for SO_3 control, flue gas humidifier, and controllers. The participant shall maintain custody until final disposition with the DOE Contracting Office. Site specific equipment, as described elsewhere, shall remain at the test site unless otherwise specified by DOE. This shall exclude items that can be reworked for uses at different sites.

Task 13 - Final Report

The participant shall prepare a final report sixty days after completion of Tasks 1-10. The final report shall summarize the results of all field sites and include the results from Tasks 8-10. The DOE COR will either provide comments and recommended changes or approve as is within 45 days of receiving the draft report. The participant shall have 30 days to submit the final version of the final report after receiving the DOE COR comments or approval.

D. Deliverables

The periodic and final reports shall be submitted as indicated in the Financial Assistance Reporting Requirements Checklist and prepared in accordance with the instructions for preparation and submission of said reports. In addition to these reports, the participant shall prepare the following deliverables:

a. Final Design Specifications for transportable mercury control system as described in Task 1.
b. Final Host Site Test Plan and Project Management Plan as described in Task 2.
c. Candidate Sorbents (if requested) as described in Task 3.
d. QA/QC Plan as described in Subtask 5.4
e. Preliminary report as described in Subtask 5.9
f. Host Site Field Test Topical Reports as described in Task 9.
g. Integrated Database as described in Task 10.1
h. Draft Economic Analysis Plan as described in Task 10.2
i. Symposium Technical Papers as described in Task 11
j. Equipment Disposition Plan as described in Task 12
k. Final Report as described in Task 13.

E. Technical Briefings/Presentations

The participant may be asked to prepare and present at least one annual briefing on the project at the DOE National Energy Technology Laboratory, located in Morgantown, West Virginia, or other COR-approved location.

F. Technical Requirements and Responsibilities

Scope Split for Mercury Control System – DOE Demonstration Sites

The ADA-ES Transportable Mercury Control System consists of two subsystems, spray cooling and carbon/sorbent injection. ADA-ES will provide the majority of the process equipment that will travel from site to site. This equipment will be sized and designed to cover the expected range of plant sizes (50-150 MW) and flue gas conditions, and has the flexibility for both baghouse and ESP applications. The exact equipment configuration to be used at a site will depend on site-specific conditions and the test matrix to be followed for that site.

Some components will be, by necessity provided by the host utility. These are components that must be sized and designed for the specific plant arrangements and ductwork configurations.

The following table lists the major items provided by ADA-ES as part of its transportable mercury control system, and those provided by the host plant. This is a preliminary projection of the hardware responsibilities. The final breakout of the responsibilities will be determined based on site visits, detailed analysis of site-specific conditions, and the test matrix to be followed at the site.

SPRAY COOLING SUBSYSTEM

ADA-ES Transportable System	Provided by Host Site
1 Pump Skid	Injection Ports
1 PLC Controls	Platform
2 Liquid Distribution Manifolds	Lance Hoist
2 Compressed air Manifolds	Injection Lances*
1 Lot Hose(300ft) & fittings	TC Array*
Thermocouple Transmitters + Junction Box	Compressed air (quantity TBD)
Misc. Expendables	480V power, 110V power (amperage TBD)
Air hose	Freeze protection
SS tubing	Signal wiring
Hot Lines	Water supply (quantity TBD)
TC ext. cable/plugs	

* Designed and supplied by ADA-ES. Purchased by Host Site (some items may be able to be re-used at other sites if size requirements are similar).

ACTIVATED CARBON (AC) / SORBENT INJECTION SYSTEM

ADA-ES Transportable System	Provided by Host Site
AC Day Bin w/ filter (300 ft3)	Injection Ports
Lime Day Bin w/ filter (300 ft3)	Sorb dist manifold
High rate AC feeder (ESP application)	Sorbent injectors*
Low Rate AC feeder (FF application)	Cherry Picker for Supersacks
Sorbent feeder	Compressed Air (quantity TBD)
Conveying Blower	480 & 110V power (amperage TBD)
Conveying Hose (300 ft) splitter and fittings	Boiler Load signal
PLC Controls	Signal wiring
Hg CEM?	
Misc. Expendables	
Hose for injectors	

MOBILE LAB/OFFICE

ADA-ES Transportable System	Provided by Host Site
Mobile Lab/Office	480V Power (amperage TBD)
	2 Telephone Lines
	Staging Area
	Assistance in Set-up
	Potable Water and Drain

ATTACHMENT C

Press Releases and Announcements

U.S. Department of Energy

DOE Fossil Energy **TECHLINE**

Issued on: August 14, 2000

New Projects Positioning Coal-Fired Utilities to
Meet Possible Mercury Control Standards
with New, Lower Cost Technologies

With the Nation's coal-burning utilities facing the possibility of tighter controls on mercury pollutants, the U.S. Department of Energy is preparing to fund two projects that could offer power plant operators better ways to reduce these emissions at much lower costs.

The department will provide just over $5.5 million to **McDermott Technology, Inc., of Alliance, OH**, and **ADA Environmental Solutions, LLC, of Littleton, CO,** to test full-scale advanced mercury control methods at several of the nation's power plants. The two firms will contribute nearly $3 million.
Mercury is known to have toxic effects on the nervous system of humans and wildlife. Although it exists only in trace amounts in coal, mercury is released when coal burns and can accumulate on land and in water. In water, bacteria transform the metal into methylmercury, the most hazardous form of the metal. Methylmercury can collect in fish and marine mammals in concentrations hundreds of thousands times higher than the levels in surrounding waters.

In June 2000, the National Academy of Sciences released a report reinforcing the importance, especially for women in their child bearing years, of heeding consumption advisories of noncommercial fish to avoid methylmercury. The Environmental Protection Agency has until December 15 to decide whether to regulate mercury from coal-fired utility boilers.

The challenge of reducing mercury emissions from power plants today is that no uniform method of technology exists. Current pollution controls were designed for other types of pollutants, and their effectiveness in reducing mercury emissions can vary from boiler to boiler. Depending upon the power plant, reduction levels can range from 90 percent to zero.

To provide more consistent and lower cost methods, the two companies will demonstrate mercury control at different points in a power plant's flue gas cleanup process. McDermott will test a technology developed jointly with its Babcock and Wilcox partner that enhances the effectiveness of "wet scrubbers" - the technology used by more than a quarter of the nation's coal power plants to reduce sulfur pollutants. ADA will test a system that works in concert with a power plant's baghouse or electrostatic precipitator to remove dust-like solid particles from a plant's exhaust gas.

The goal is develop technologies by 2005 that will be capable of cutting mercury emissions 50 to 70 percent at well under one-half of today's costs. Both projects were selected from the first of two rounds of competitions the Energy Department began in March, 2000. In October, the department will announce selections of more novel, less developed control systems for testing at pilot plant scales. The deadline for these project proposals is August 31.

McDermott Technology, Inc., in conjunction with Babcock and Wilcox
In this project, Babcock and Wilcox Company will demonstrate a cost-effective mercury removal system with its research affiliate McDermott Technology, Inc. The technology, expected to be applicable to coal-fired power plants equipped with wet scrubbers, will be tested at full scale at two sites: 1) Michigan South Central Power Agency's 55-megawatt Endicott Station in Litchfield, Michigan, and 2) Cinergy Corporation's 1300-megawatt Zimmer Station near Cincinnati.

The Babcock and Wilcox/McDermott technology adds very small amounts of a liquid reagent to the scrubbing solution to attain its target of 90 percent mercury removal at costs one-half to one-fourth those of today's commercially available activated carbon mercury removal methods.

The project is expected to begin in October and last for 18 months. It is estimated to cost $1.75 million, with $1.2 million provided by the Energy Department. The project team includes the two utilities that will host the tests and the Ohio Coal Development Office. If the project proves successful, Babcock and Wilcox will offer mercury control technology for commercial use in both new and existing wet flue gas scrubber systems.

The technical contact is Dennis K. McDonald, (330) 734-1727, e-mail McDonald@ppg.mcdermott.com.

ADA Environmental Solutions

ADA Environmental Solutions will develop a portable system that will be moved to four different utility power plants for field testing. Each of the plants is equipped with either electrostatic precipitators or fabric filters to remove solid particles from the plant's flue gas.

ADA's technology will inject a dry sorbent, such as fly ash or activated carbon, that adheres to the mercury and makes it more susceptible to capture by the particulate control devices. A fine water mist will be sprayed into the flue gas to cool its temperature to the range where the dry sorbent is most effective. Because cooling the flue gas can increase the formation of corrosive sulfur trioxide, ADA's technology also includes a reagent injection system to control the buildup of sulfur trioxide if needed.

PG&E Generating is providing two test sites that fire bituminous coals and are both equipped with electrostatic precipitators and carbon/ash separation systems. Wisconsin Electric Power Company is providing a third test site that burns Powder River Basin coal and has an electrostatic precipitator for particulate control. A fourth plant, equipped with a fabric filter, will be added to the test program.

The 36-month project will receive $4.5 million from the Energy Department. ADA Environmental Solutions and an 11-organization support team will provide an additional $2.2 million. The technical contact is Michael D. Durham, (303) 734-1727, e-mail: miked@adaes.com

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Contact: Michael Durham (ADA-ES) or Mark McKinnies (Earth Sciences)

ADA-ES Begins Work on Installing and Testing Mercury Emissions Controls at Coal-Burning Power Plants as

LITTLETON, COLO. – December 14, 2000 – Environmental technology and specialty chemical company ADA-ES, a subsidiary of Earth Sciences (OTCBB:ESCI), has begun work on a comprehensive mercury emissions control program to evaluate the technology that power generating companies will use to comply with new mercury regulations. The Environmental Protection Agency (EPA) announced on December 14 their decision to regulate mercury emissions from the nation's coal-fired power plants.

After signing a final $6.8 million cooperative agreement this month with the U.S. Department of Energy National Energy Technology Laboratory (DOE/NETL), ADA-ES began developing test plans for power plants to test mercury emission control technologies. The EPA's new regulations require coal-fired power plants to reduce mercury emissions for the first time. There will be a three-year period to develop proposed rules, followed by one year to finalize the proposal, with full compliance required in 2007.

Reports estimate that these new regulations will cost the power generating industry as much as $5 billion per year to reduce mercury emissions. Much of these costs will be borne by power plants that burn low-sulfur coal and use particle collection devices instead of wet scrubbers as part of their air pollution control configurations. The four plants that will be evaluated during the ADA-ES program are typical of this type of application, which covers about 75 percent of the nearly 1100 units that are impacted by the regulations.

"These new regulations could potentially be quite expensive for power generating companies with coal-burning power plants," said Michael Durham, president of ADA-ES. "We are working diligently with our power generation partners to develop and test technology that will allow these power plants to meet environmental standards in the most cost-effective way possible. ADA-ES has a history of developing successful pollution control technologies that help power companies reduce their operational costs while meeting environmental regulations."

Under the DOE/NETL cooperative agreement, ADA-ES is working in partnership with PG&E National Energy Group, Wisconsin Electric, a subsidiary of Wisconsin Energy Corp., Alabama Power Company, a subsidiary of Southern Company (NYSE:SO) and EPRI. The contract, which was announced last month, includes $2.3 million of industrial cost share, which will be provided by power generating companies, EPRI and equipment vendors.

The ADA-ES program will focus on control technology based upon injecting chemical sorbents into the flue gas to react with mercury. These sorbents are then collected in existing downstream particulate control equipment. ADA-ES will head a team of the country's leading mercury control experts seeking to maximize effectiveness of the sorbents and minimize costs to curtail mercury emissions from power plant flue gases. Providing mercury control sorbents is expected to be a $1 billion per year industry once the new regulations are fully implemented.

ADA-ES currently provides commercial air pollution control technology that is very similar to sorbent-based mercury emission control. ADA-ES installs equipment that injects proprietary chemical products into the flue gas to enhance particle collection. These chemicals are subsequently captured along with the dust in the existing particulate control equipment to help boiler operators meet current environmental regulations on particulates while burning low-cost Western coals.

About ADA-ES
Headquartered in Littleton, Colo., ADA-ES is an environmental technology and specialty chemical company that brings 25 years of experience to improve responsible profitability for electric power and industrial companies through proprietary products and systems that mitigate environmental impact while reducing operating costs. ADA-ES can be reached at 303-734-1727 or email at ir@adaes.com.

ADA-ES is a subsidiary of Earth Sciences, whose common stock trades on the OTCBB under the symbol ESCI.

This press release may contain forward-looking information within the meaning of Section 27A of the Securities Act of 1933 and Section 21E of the Securities Exchange Act of 1934. The United States Private Securities Litigation Reform Act of 1995 provides a "safe harbor" for such forward-looking statements in this document that are based on information the Company believes reasonable, but such projections and statements involve significant uncertainties. Actual events or results could differ materially from those discussed in the forward-looking statements as a result of various factors including but not limited to changing market demand for ADA-ES chemicals and systems and changes in technology, laws or regulations, demand for the company's securities, and other factors discussed in the company's 1999 Form 10-KSB and recent Form 10-QSBs.

DOE selects Alabama Power plant for mercury testing

Monday, December 11, 2000
Contact: Sandi George, (205) 226-1416
skgeorge@southernco.com

BIRMINGHAM -- Alabama Power has been selected by the U.S. Department of Energy to participate in the nation's first full-scale program to test advanced mercury control technologies.

The company, a subsidiary of Southern Company, will install and test an innovative mercury control process at its Gaston generation plant near Wilsonville, Alabama.

As part of the process, carbon will be injected into an existing ash collection system already installed on the plant site. The carbon will absorb the mercury, which could result in substantial emissions reduction.

"This project re-affirms the commitment of Alabama Power and Southern Company to explore ways to provide our customers with reliable, affordable electricity that is cleaner than ever," said Alabama Power Senior Vice President Jerry Stewart, who is responsible for power generation. "We want to be at the forefront of developing efficient and effective control solutions."

The system to be used by the Gaston plant is a transportable mercury control technology developed by ADA-Environmental Solutions, a subsidiary of Earth Sciences, Inc., based in Colorado. According to the DOE's National Energy Technology Laboratory, which is spearheading the project, the goal is to develop a cost-effective technology that will allow the electric utility industry to reduce mercury emissions from power plants by up to 70 percent of current levels.

"Coal as an energy source plays an important role in the nation's fuel diversity, which helps ensure electricity price stability and reliability," said Scott Renninger, project manager at DOE's National Energy Technology Laboratory in Morgantown, W.Va. "Finding a cost-effective and technologically-feasible method of controlling mercury emissions not only improves the environmental operations of generating plants but also secures the important role that these plants play in our nation's electric supply."

Alabama Power and Southern Company will work with ADA-ES, the Electric Power Research Institute (EPRI), Hamon Research Cottrell and two other electric generating companies on the project. The $6.7 million project includes three other generating units located in Massachusetts and Wisconsin. The DOE will fund 70 percent of the project costs with Alabama Power and the other participating companies co-funding the remaining 30 percent.

Testing at Alabama Power's Gaston plant will begin the first quarter of 2001. "We have made great progress in controlling emissions of nitrogen oxides. The challenge of controlling mercury, which is found in only trace quantities in coal, is even more difficult," said Dr. Charles Goodman, senior vice president, research and environmental affairs for Southern Company. "We are excited about the chance to develop this next generation of emissions control technologies. We take pride in our continuing effort to play a leadership role in developing innovative approaches to lessening the impact of our operations on the environment." Since the early 1970s, Alabama Power has invested more than $1.3 billion in environmental-protection equipment, research and development.

Alabama Power and Southern Company are recognized as pioneers in advanced environmental control technologies. The company's Power Systems Development Facility, also located in Wilsonville, is researching innovative technologies that could allow power plants to make the same amount of electricity while burning one-third less coal. The technologies also remove or reduce sulfur dioxide, nitrogen oxides, carbon dioxide and particles from the coal combustion process.

Alabama Power provides affordable, reliable electric service to 1.3 million customers in the lower two-thirds of Alabama. Alabama Power is a subsidiary of Atlanta-based Southern Company (NYSE: SO), an international energy company that operates more than 48,000 megawatts of electric generating capacity worldwide. Southern Company is the largest producer of electricity in the United States and one of the world's largest independent power producers.

# # # # #

FOR IMMEDIATE RELEASE September 7, 2000

CONTACT: Lisa Franklin, PG&E National Energy Group (617) 788-3643

EDITORS: *Please do not use "Pacific Gas and Electric" or "PG&E" when referring to PG&E Corporation or its National Energy Group. The PG&E National Energy Group is not the same company as Pacific Gas and Electric Company, the utility, and is not regulated by the California Public Utilities Commission. Customers of Pacific Gas and Electric Company do not have to buy products or services from the National Energy Group in order to continue to receive quality regulated services from Pacific Gas and Electric Company.*

DOE SELECTS PG&E CORPORATION'S MASSACHUSETTS PLANTS FOR ADVANCED MERCURY EMISSIONS CONTROL TECHNOLOGY TESTING

BOSTON, MA -PG&E Corporation's **(NYSE: PCG)** National Energy Group (PG&E NEG) has been selected by the U.S. Department of Energy (DOE) to participate in the nation's first full-scale mercury emissions pilot program, which will evaluate the use of control technology for coal-burning power plants. The company has made a $600,000 commitment to conduct field testing of mercury control technology at the 750-megawatt Salem Harbor Station in Salem, Massachusetts and the 1,586-megawatt Brayton Point Station in Somerset, Massachusetts. Currently, the nation lacks an effective technology for controlling mercury emissions from coal-fired power plants.

"This project re-affirms our commitment to environmental leadership and to finding new ways to reduce the environmental impact of electricity production," said PG&E National Energy Group Vice President and Chief Administrative Officer for the Northeast Steven A. Wolfgram. "Mercury emissions control has emerged as a significant environmental issue over the past few years. We want to be at the forefront of closing the gap between our goals of controlling mercury emissions and the current lack of knowledge about how to do so."

The U.S. Environmental Protection Agency (EPA) must determine whether to regulate mercury emissions from coal-fired power plants by December 15, 2000. However, a 1998 EPA report entitled "Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units - Final Report to Congress" concluded that no feasible technologies currently available could effectively reduce mercury emissions from coal-fired facilities.

The DOE proposed this joint government-business funded project to offer coal power plant operators better ways to reduce these emissions at much lower costs. According to the DOE's National Energy Technology Laboratory, which is spearheading the project, the goal is to develop a cost-effective technology that will allow the industry to reduce annual mercury emissions from power plants by 50 to 70% of current levels.

"Coal-fired power plants play an important role in the nation's fuel diversity, which helps ensure electricity price stability and reliability. Finding a cost-effective and technologically-feasible method of mercury emissions control will improve the environment while also securing the important role that coal-fired power plants play in our nation's electric supply," says Scott Renninger, Project Manager at DOE's National Energy Technology Laboratory in Morgantown, West Virginia.

PG&E NEG will work in partnership with the lead contractor ADA-Environmental Solutions, a Colorado-based pollution control technology company, the Electric Power Research Institute (EPRI), and two other generating companies to design and engineer systems to reduce mercury from stack emissions. Energy and Environmental Strategies, a Shrewsbury, Massachusetts-based environmental consulting firm helped prepare the bid and will act as a subcontractor on the project.

The Salem Harbor and Brayton Point stations will use a portable mercury control system developed by ADA-Environmental Solutions to test mercury controls on bituminous coals. The project was selected in the first of two rounds of competitions that the Energy Department began in March 2000. The total project cost will be $6.7 million, and will be paid for by the DOE, PG&E NEG, and the other companies participating in the project.

"We have made great progress in controlling traditional emissions like nitrogen oxides and sulfur dioxide. Now we face the more difficult challenge of controlling mercury, which is found in miniscule quantities in a large amount of fuel," Wolfgram said. "We are excited about the chance to develop this next generation of emissions control technologies that can be used throughout the industry. We take pride in our continuing effort to produce clean, reliable, and low cost energy."

PG&E NEG is recognized for being a pioneer in advanced environmental control technologies. In 1994, the company was the first in the country to use Selective Catalytic Reduction (SCR) in a new commercial coal-fired power plant, resulting in a 60% reduction in nitrogen oxide emissions from the average coal plant. This use of SCR has set a standard for all new coal plants, and it is now the most widely recognized technology to meet new regulatory requirements for nitrogen oxide reductions.

PG&E Corporation with 1999 operating revenues of nearly $21 billion and operations in 27 states, markets energy services and products throughout North America through its National Energy Group. The Corporation's National Energy Group has a significant presence in the New England area with ownership in 20 power plants and one of the most active power trading businesses in the region.

Wisconsin Energy Corporation (ticker: WEC, exchange: New York Stock Exchange) News Release - 17-Aug-2000

Wisconsin Electric participates in mercury removal project

Company's Pleasant Prairie Power Plant chosen as demonstration site

MILWAUKEE - The U.S. Department of Energy has selected Wisconsin Electric's Pleasant Prairie Power Plant (P4) to participate in the nation's first full-scale mercury emissions control program for coal-burning power plants. ADA-Environmental Solutions of Littleton, Colo. will conduct the program with support from the Electric Power Research Institute (EPRI). A utility to be named will also be a host site.

The field tests at P4 would involve injecting activated carbon and other sorbent materials into one fourth of the flue gas flow ahead of the particulate control device and measuring the mercury reduction. In addition, the program would evaluate the impact on plant equipment and on ash properties. WE has already been conducting a bench scale mercury removal demonstration at P4 this summer. Participating in the DOE program will be the next step to gain additional technical information and enhance the understanding of the process.

"Wisconsin Electric takes the mercury issue very seriously," said Kris Krause, vice president, fossil operations. "We're working hard to develop cost effective solutions while providing our customers with safe, reliable electricity. We look forward to seeing the results of this program."

The proposed total cost for the program is $6.8 million. The DOE will pick up the majority of the cost with EPRI and the participating utilities contributing a third of the funds.
WE recently set a goal to reduce mercury emissions at it's power plants by 40% over the next ten years.

A subsidiary of Wisconsin Energy Corp., Wisconsin Electric provides electric, natural gas and/or steam service to about 2.4 million people in southeastern Wisconsin (including the Milwaukee area), the Appleton area, the Prairie du Chien area, and portions of northern Wisconsin and Michigan’s Upper Peninsula. Please visit our Web site at www.wisconsinelectric.com.

NEWS & ANALYSIS
@power online

8/17/2000

DOE picks team for mercury emission control program
EPA likely to call for mercury emissions regulations in December

The U.S. Department of Energy (DOE) recently selected a team of companies to field test mercury-emissions controls for coal-fired power plants. The proposed US$6.8 million contract, which includes US$2.3 million of industrial cost share, represents the American government's first step toward defining technology platforms for utility companies to use in meeting expected mercury regulations from the U.S. Environmental Protection Agency (EPA).

EPA, thinking of regulating mercury for a decade, must decide by Dec. 15 whether it is appropriate and necessary to regulate mercury from coal-fired boilers. If mercury it does call for mercury regulations, it will dramatically affect the way coal-burning power generators operate. Currently, no uniform methods or technologies to control mercury from power plant flue gas emissions exist.

Under the contract, ADA-ES (ADA Environmental Solutions), a subsidiary of Earth Sciences, PG&E National Energy Group, Wisconsin Electric Power Company, EPRI, and a third utility plan to work together to design and engineer systems to maximize effectiveness and minimize costs to curtail mercury emissions from power plant flue gases.

Reports estimate that mercury control will open up a US$5 billion per year business if EPA regulates the substance. Much of these costs will be associated with power plants, including the four selected by the team for evaluation, that don’t have wet scrubbers as part of their air pollution control configurations. This is the case at 75% of the 1,100 units expected to come under the new regulations.

Specifically, ADA-ES plans to develop and field test a portable mercury-control system on four different power plant configurations that use electrostatic precipitators or fabric filters to remove particulates. The system sprays a fine mist of water into the gas stream to lower temperatures and increase effectiveness of dry sorbents that are injected to remove remaining mercury compounds. ADA-ES expects the portable system field tests a to reduce costs and minimize the amount of equipment.

DOE, which conducted a competitive search for team participants, selected ADA-ES for this portion of the program based on its experience in flue-gas conditioning and its history of using DOE technology to create commercial products, said Dr. Michael Durham, ADA-ES president.

“ADA-ES brings to this important public-private initiative a substantial track record in helping power generators remain competitive and responsible in a deregulated environment," Durham said. "We understand the unique dynamics of environmental technology and how it can be applied to serve the best interests of both the utility industry and its customers."

According to Jeffrey C. Smith, executive director of the Institute of Clean Air Companies (ICAC), EPA seems likely to require coal-fired utility boilers to control mercury emissions, especially following a recent report of the National Academy of Sciences, which made that recommendation.

“Both the air pollution control industry and policymakers have targeted cost-effective control of mercury emissions as a high R&D priority,” Smith said. “This DOE program should contribute to the body of knowledge available to all affected parties on cost-effective mercury control technologies."

Edited by April C. Murelio
Managing Editor, Power Online